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# THE CHARACTERISTIC FUNCTION OF SP-POTENTIALS FOR PERMEABLE INHOMOGENEOUS SURROUNDINGS

# CHARAKTERISTICKÁ FUNKCE POTENCIÁLŮ SP PRO PROPUSTNÉ NEHOMOGENNÍ PROSTŘEDÍ

**Abstract**

The method of SP-potentials has its characteristic function. It was up to now written for condition that there is no invasion into bed. However, such condition in real situation is not so frequent. Most of porous beds are presented like those having invasion zone which has factor remarked as the depth of invasion zone. This paper studies an influence of invasion of the mud filtrate into bed on registration of the SP-potentials.

Key words: SP-potentials, invasion, mud filtrate, the depth of invasion zone, bed thickness, well-logging

**Abstrakt**

Metoda potenciálů SP má svoji charakteristickou funkci. Ta až dosud byla popsána pro podmínku, že nedochází k filtraci do vrstvy. Ale taková podmínka není v reálné situaci příliš častá. Většina pórovitých vrstev se prezentuje jako vrstvy, které mají zónu filtrace charakterizovanou faktorem označeným jako hloubka zóny filtrace. Tato práce studuje vliv pronikání filtrátu výplachu do vrstvy na registraci potenciálů SP.

## 1 INTRODUCTION

Exchange of ions is made by diffusion of ions through the membrane boundary between mud filtrate and the formation water. The mentioned membrane exists in a certain distance from the borehole wall. The fewer rocks are porous, the deeper there is invasion and thanks to it the lower SP-potentials are. The highest values are observed for those porous beds having no invasion into bed, i.e., Di = d.

It is not only the shift of the boundary between mud filtrate and formation water inwards bed. Invasion into bed is accompanied by cementation of pores and cracks with very fine particles of clay. The deeper invasion is the higher shaliness of bed is. The bed gets less permeable and its radioactivity is simultaneously higher too. Consequence of that is that deflections of SP-potentials for sandy bed are lower thanks to higher shaliness. If the depth of invasion is classified like infinitely-deep, we can expect that deflection of the SP-method will be zero.

## 2 THEORY OF THE CHARACTERISTIC FUNCTION

Fundamental formula is the formula describing Nernst's potential being on the membrane boundary:

$$E_{SP} = \varepsilon_{SP} \times f\left(\bar{z},\ \bar{h},\ \bar{\Delta},\ \bar{D}_i\right), \tag{1}$$

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where ESP = SP-potential being on the wall of borehole [mV],

εSP = Nernst's potential on the membrane boundary [mV], and

$f\left(\bar{z},\bar{h},\bar{\Delta},\bar{D}_i\right)$ = the characteristic function of SP-potentials.

The characteristic function is defined like that:

$$f\left(\bar{z},\bar{h},\bar{\Delta},\bar{D}_i\right)=\left(\frac{1}{\pi}\right)\times\left\{\frac{\left(2\bar{z}+\bar{h}\right)}{\sqrt{\left(2\bar{z}+\bar{h}\right)^2+\left(2\bar{\Delta}+\bar{D}_i\right)^2}}\times K\left\{\frac{4\bar{\Delta}}{\sqrt{\left(2\bar{z}+\bar{h}\right)^2+\left(2\bar{\Delta}+\bar{D}_i\right)^2}}\right\}\right.$$
$$\left.-\frac{\left(2\bar{z}-\bar{h}\right)}{\sqrt{\left(2\bar{z}-\bar{h}\right)^2+\left(2\bar{\Delta}+\bar{D}_i\right)^2}}\times K\left\{\frac{4\bar{\Delta}}{\sqrt{\left(2\bar{z}-\bar{h}\right)^2+\left(2\bar{\Delta}+\bar{D}_i\right)^2}}\right\}\right\}, \tag{2}$$

$$\bar{D}_i=\frac{D_i}{d}, \tag{3}$$

where Di = the depth of invasion zone [m],

d = the borehole diameter [m],

Δ = eccentricity, i.e., the distance between axis of borehole and axis of tool [m],

h = thickness of bed [m], and

z = the distance between the centre of bed and the centre of electrode [m].

In formula (2) all dashed factors are standardized by the borehole diameter like it is in formula (3) for factor Di .

Note, please, that action of invasion zone, horizontal direction, is presented with term $\left(2\bar{\Delta}+\bar{D}_i\right)$, whereas, action of the bed thickness, vertical direction, has term $\left(2\bar{z}\pm\bar{h}\right)$. Factors quantifiable in the horizontal direction are in the first term, whereas, factors quantifiable in the vertical direction in the second term.

You can analyze formula (2). For the bed having no invasion it holds that Di = d which means that $\bar{D}_i\to 1$.

$$f\left(\bar{z},\bar{h},\bar{\Delta},1\right)=\left(\frac{1}{\pi}\right)\times\left\{\frac{\left(2\bar{z}+\bar{h}\right)}{\sqrt{\left(2\bar{z}+\bar{h}\right)^2+\left(2\bar{\Delta}+1\right)^2}}\times K\left\{\frac{4\bar{\Delta}}{\sqrt{\left(2\bar{z}+\bar{h}\right)^2+\left(2\bar{\Delta}+1\right)^2}}\right\}\right.$$
$$\left.-\frac{\left(2\bar{z}-\bar{h}\right)}{\sqrt{\left(2\bar{z}-\bar{h}\right)^2+\left(2\bar{\Delta}+1\right)^2}}\times K\left\{\frac{4\bar{\Delta}}{\sqrt{\left(2\bar{z}-\bar{h}\right)^2+\left(2\bar{\Delta}+1\right)^2}}\right\}\right\}. \tag{4}$$

If Di >> d it holds that $\bar{D}_i\to\infty$. You can insert there that $\left(2\bar{\Delta}+\bar{D}_i\right)=\bar{D}_i\to\infty$.Then it is valid that K { } = π/2. In such case you will get that $f\left(\bar{z},\bar{h},\bar{\Delta},\bar{D}_i\right)=0$. The exchange of ions is realized deep inside of bed, not on the wall of borehole; pores are cemented with particles of clay and it is why that permeability of bed is lower.

This confirms that for increasing depth of invasion the characteristic function tends to zero and consequence of that is that ESP → 0. It remembers you those events when the bed of clean and low-permeable sandstone was classified like shale and in spite of that was perforated.

This can happen when customer having low finances wants only SP-curve without any resistivity-curves, then side wall coring and, finally, opening of bed by perforating. Geologist well-knowing the borehole section orders to take too side-wall cores from the interval classified like shale. And if the horizons after SP are shaly and they have very low inflow, whereas, the clean sandstone, thanks to a well-made and deep perforation, has a power source of fresh water; it can be devastating for your image of log analyst.

Due to formula (2) it is possible, too, to deduce the formula for the characteristic function of the SP-lateral. I refer to the before published my papers dealing with this problem.

## 3 CONCLUSIONS

On the base of made analysis I came to the following conclusion:

Exchange of ions is realized on the membrane boundary being far of the wall of borehole. This makes less registration of SP-potentials being on the wall. For very deep invasion it holds that the registered SP-potentials are zero.

### REFERENCES


[1] RYŠAVÝ, F., (1995): Some new facts about the self-potential methods, Zemní plyn a nafta, 40, 1, pp. 89-92.

[2] RYŠAVÝ, F., (1996): A new approach to SP-reduction factor in view of electrochemical activity of rocks, Zemní plyn a nafta, 40, 4, pp. 309-315.

[3] RYŠAVÝ, F., (1997): Quantitative interpretation of the self-potentials log, Zemní plyn a nafta, 42, 1, pp. 39–44.


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